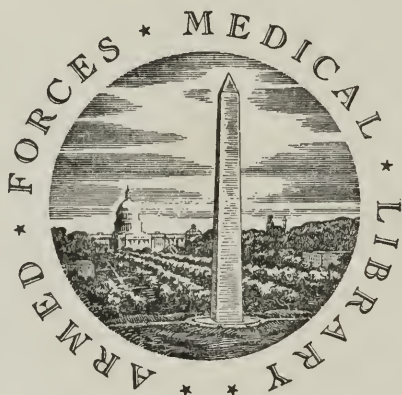


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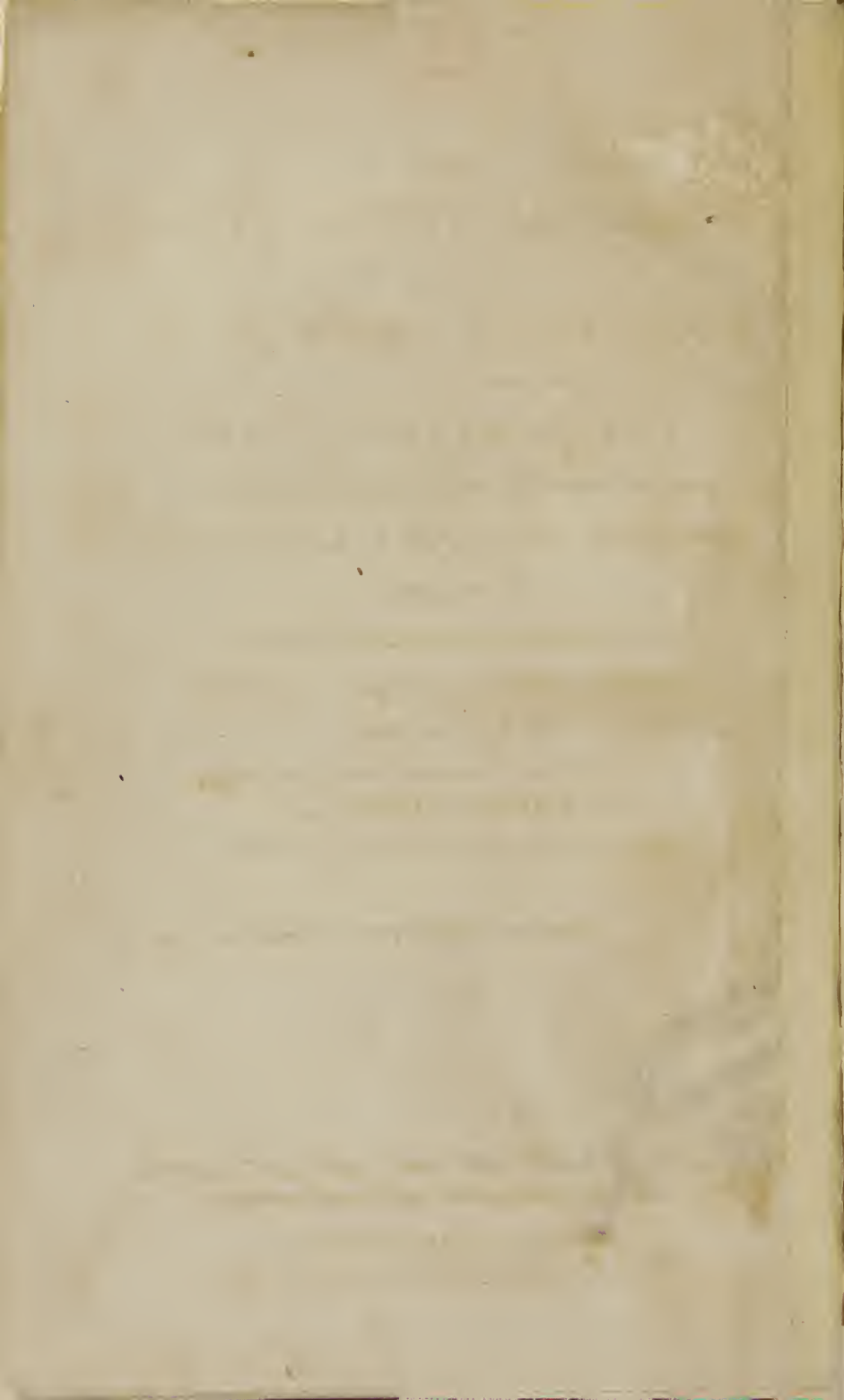




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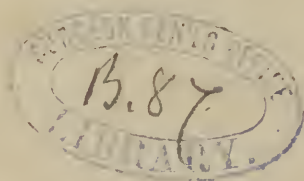
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AN
INAUGURAL DISSERTATION
ON THE
PRINCIPLE OF ANIMATION,
READ AND DEFENDED AT A
PUBLIC EXAMINATION,
HELD BY THE MEDICAL PROFESSOR, BEFORE THE
HON. JOHN WHEELOCK, L. L. D. PRESIDENT,
AND THE
GOVERNORS OF DARTMOUTH COLLEGE,
FOR THE DEGREE OF BACHELOR IN MEDICINE,
JULY 18, 1799.

BY DANIEL ADAMS, A. B.

What can we reason but from what we know?—POPE.



HANOVER, NEW-HAMPSHIRE,
Printed by MOSES DAVIS.—1799.

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NATHAN SMITH, A. M.

PROFESSOR OF MEDICINE AT DARTMOUTH UNIVERSITY,

AND

CORRESPONDING MEMBER

OF THE

LONDON MEDICAL SOCIETY,

THIS

DISSERTATION

IS

RESPECTFULLY INSCRIBED,

BY HIS

MUCH OBLIGED

AND

GRATEFUL PUPIL,

THE AUTHOR.

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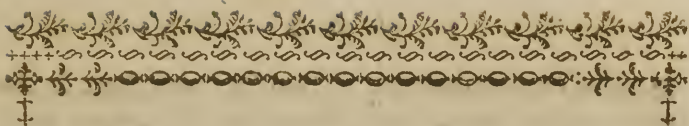
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INAUGURAL DISSERTATION.

THE healing art presents an extensive field for speculation. No science embraces a greater variety of principles, or affords more subjects of philosophical disquisition. Its inquiries extend to all the operations of nature ; its objects are scattered far as the solar light.

Notwithstanding the painful researches and unwearyed investigations, which have been made to improve this branch of knowledge, so engaging in itself, and so important to the interests of society, still this art is yet incumbered with the swaddling clothes of infancy.

Systems of medicine have changed with times, and the phenomena of diseases have been explained on principles of the reigning philosophy ; the business of one age has been to refute the reasonings of a preceding, so that what began to be called a science, in the days of Hypocrates, is yet established on little better foundation than that of hypothesis and conjecture.

The study of nature has been too much neglected, and those intimations of her designs, which, in her operations, she is continually suggesting to every contemplative mind, have been too little regarded.— From this unpardonable neglect, much false theory has crept into medicine ; reason and reflection have given way to fancy, while the pedantry of philosophy, and an ambition to establish a favourite system has often triumphed over plain truths, obvious facts,
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and clear demonstration. That has been done in the closet, which should have been done in the open field, and physicians have sought for that information on the theatre of the anatomist, which is only to be found on the theatre of nature.

Notwithstanding many false theories have been offered to the public, which have served in some degree to confound the inexperienced, and oftentimes to misguide the more understanding, yet one advantage has been realized ; for by giving a new presentation of facts, they have often suggested useful and important ideas in medicine. Every theory, moreover, however extravagant, serves this important purpose, that it excites inquiry ; and the author, if he shall have conducted his reasoning by experiments and observations, will have some claim to the candour of the world, although it should afterwards appear, he had been too hasty in his conclusions.

In this field now open before us, the *principle of animation* becomes a subject of curiosity and useful inquiry. There is nothing in nature, which exhibits to our senses such a variety of striking phenomena, as life. It has been the wonder of ages ; philosophers have contemplated it with admiration, and naturalists have acknowledged, that the utmost researches of human sagacity were inadequate to an understanding of its mystery.

That mankind can ever arrive to so much information, and such an acquaintance with the operations of nature, as to be able to answer every inquiry on this important subject, is quite improbable ; at present we are sure the stock of human knowledge is too scanty for so much understanding. Still, however, we have grounds for supposing, that human genius is not bounded by those narrow limits, which at present mark our knowledge on this subject ; we have the

means

means of knowing the instruments, by which nature does her work, although we may not be capable of understanding completely the particular mode of her operations ; and it is not unphilosophical to suppose, that the principle of animation may be detected, although some things in the economy of life should still remain lasting expressions of the limited capacity of man.

Every one, in the exercise of his senses, feels himself capable to distinguish living beings from those possessing no life ; but to give an explicit definition of life has been attended with some difficulty, even with philosophers. Dr. PLENK has defined life, *the property of acting from an intrinsic power*. This appears not sufficiently definite, as it does not distinguish between *vitæaction*, and that *action*, which takes place by attraction and combination in various other bodies, destitute of life. Dr. BROWN has been less exceptionable ; but, in his definition, he does not tell us what are those *phenomena* peculiar to the living state, which characterize animate beings.

Observation teaches us, that all living existences are organic ; that water, heat, air, and various other substances external to them, as well as those contained within their own vessels, do excite in them certain actions ; that by those actions they have a power of receiving, by organs adapted for that purpose, portions of these stimulating substances, and thereby causing them to undergo such changes, as shall assimilate them to their own nature and substance. We, then, come to this understanding of animate beings : they are organized bodies, excited to action by substances external, thereby assimilating to their own constitution and nature, things of different and opposite natures, in a way so as to continue their existence, produce their growth, and perpetuate their species.

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This ability, which organized bodies have, of being excited to perform those actions, which are characteristic of life, is called *irritability*. This is the same; whether we consider the contraction of fibres irritated by mechanical impressions, or that action, by which fluids are taken up by the vessels, the secretions performed, and excrementitious parts thrown off. It is this irritability, which characterizes life; exists where that exists; and, as soon as the former is destroyed, the latter becomes extinct.

But what that may be, which gives to organized bodies the capacity of being excited, or on what their life depends, has for a long time agitated the schools of medicine; philosophers have kindly afforded their aid in this important inquiry, still the subject is clouded with doubts, and perplexed with controversy.—Both physicians and philosophers have been pretty unanimously agreed, that a certain *something* does constantly pervade the whole system, and give life and activity to every fibre. The ancients early adopted this opinion. This subtle fluid they called the *Pabulum Vitæ*. The same is the *Anima Mundi* of Plato, the *Archæus* of Helmot, the *Vis Medicatrix* of Cullen, the *Excitability* of Brown, and the *Spirit of Animation* of Darwin. The striking contrast, exhibited in the different appearances of living and dead animals, naturally inculcates this idea. In both we find the same organization, the same solids, and the same fluids, with this surprising difference, however, that in the former there is a constant ability to action, while the latter is utterly deprived of this power. This ability to action must depend on a cause, this cause must be something, but what this may be, to the operation of which, are to be attributed so many phenomena in the œconomy of life, it is not at present agreed, and how it is introduced into the system, and there operates to produce its effects, is a subject of still greater controversy. Some have

have supposed it to be a pure ætherial spirit, equally pervading all space, and all bodies. Some have thought it might be fire, others that it might be electricity, while many have supposed it to be an extremely subtle fluid, secreted in the brain, and thence transmitted thro' the nerves to every part of the body.

These theories, however ingenious they may be, do not explain to our satisfaction the phenomena of life; neither do they reconcile those facts, which have been ascertained by observation and experiment; and, consequently, cannot be supposed to have arisen from demonstrated truths; and a careful attention to the circumstances attending life.

Our observations, in reply to present existing theories, will be directed to show, First, the uncertainty, that the principle of animation is an ætherial spirit of such extreme subtlety, as to pervade indifferently all bodies. Secondly, the improbability of its being a secretion of the brain.

This first hypothesis, which attributes life to an ætherial spirit, pervading indifferently all substances; is liable to many objections. It does indeed seem quite superfluous to attempt any refutation of a theory, so much the work of fancy, and wholly detached from experiment and observation. What appears to have led philosophers to adopt such an one, was the necessity of attributing the phenomena of life to something. Still there was nothing in the system of nature, with whose properties and qualities they were acquainted, to which, with fairness, they could attribute such marvellous effects. The alternative, then, was to acknowledge their incapacity to understand so deep a mystery, or else to attribute animation to the agency of something yet unknown. They did the latter, and, consequently, taught mankind to believe their powers of life and activity depended on *something*, whose existence they have neither proved, nor rendered probable to be

any where but in the imagination of its projectors.—Examine the writings on medicine, from the days of Hypocrates to the present time, not one fact is adduced to substantiate this hypothesis, which may not be more rationally accounted for on other principles.—Nor indeed do they plead as an excuse, for their opinion, that it is supported by observation, or experiment; in their ignorance, only, can we find an apology. So far from affording any light on the subject, this does but involve us in deeper obscurity, and rivets on our minds the chains of perpetual ignorance, by assigning that to be the cause of animation, of which it is not possible we should have any knowledge.

Disgusted with a theory so unsatisfactory, others have assumed another hypothesis, now become more general, although, perhaps, no less false, which is, that the principle of animation is a fluid secreted in the brain, and thence transmitted by the nerves to every part of the body. That this supposition is premature and erroneous, I think will be obvious to every one, who reflects with soberness, judges with candour, and reasons with attention.

There are abundance of circumstances to convince us, that the brain is an organ of vast importance in the animal œconomy. The disorders produced in the system, by affections of this part, are such as might well be thought, would have led many to suppose this to be the seat of life. But such is the reciprocal relation and dependence subsisting between each organ of our bodies, that it is oftentimes extremely difficult, if not impossible, to distinguish the appropriate function of each, and to know its just agency in the system.—The brain cannot perform its functions without the action of the heart, and the consequent circulation of the blood; and without the mysterious influence of the former, the latter would soon cease to move: Nor can either of these continue their operations without
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the act of respiration ; and were it not for the wonderful process of digestion and assimilation, all other powers would be in vain to maintain life. It requires, therefore, a particular attention to the different parts, organization, faculties, and powers, of different animals, to learn the importance of each, and its just agency in the system.

We have the fullest conviction, that the brain and its appendages, the nerves, are the seat of sensibility ; and that, these are the medium of all our sensations and volitions. It exercises, therefore, one of the most conspicuous functions in the animal œconomy ; confounding this with irritability, a thing before described, and very different, has led to many mistakes in physiology.

Was it so that irritability depended on the same cause, as sensibility, we should expect to find those parts most irritable, to which were distributed the greatest proportion of nerves. This, however, is not the case ; the heart is the most irritable part of the body, notwithstanding its nerves are not numerous. It is always so in animals, that those parts, or muscles, designed for sensation, or voluntary motion, are most abundantly supplied with nerves ; while those parts, which receive the greatest number of blood vessels, as the heart and intestines, possess the greatest irritability.

Further to illustrate this idea, we know, that by passing a ligature round a nerve, or by dividing it with a knife, we destroy all sensation and voluntary motion in that part, which has its communication with the brain thus interrupted ; still, however, it does not lose its irritability. Indeed, so tenacious are parts of this power, and so independently of the brain do they exercise it, that this organ may be completely destroyed, and they still continue to exhibit evident contractions. The heart and intestines, after
being

being removed from the body, will have their motions excited by mechanical irritations.

There have been many instances of the nerves of one part having been destroyed, or their functions suspended, while yet that part has been able to exercise those functions, which were necessary to the continuance of life. This has often been the case in paralytic limbs. That the functions of the nerves are completely suspended, we are certain; for the patient can exert no voluntary motion, nor is he sensible to any impression of external bodies; and that the part is possessed of irritability and life, we are equally certain; because there are often involuntary contractions of the fibres, the blood circulates, and absorption and secretion regularly take place.

What makes this, if possible, more certain is, that no putrefaction occurs, which in all cases commences so soon as the animal, or a part is dead.

Dr. MUNRO, that indefatigable anatomist, affords us a very conclusive argument, in his experiments on the nerves, one of which I beg leave to relate in his own words.

“In several frogs after cutting off the back part of the six undermost true vertebræ, I took out all that part of the spinal marrow with the cauda equina, which they cover. The lower extremities were rendered insensible to common injuries, and lay motionless, yet the frogs lived several months thereafter, and the wounded parts on their backs cicatrized, and the bones of their legs which I fractured united, the blood circulating freely in their vessels.”

In these animals the functions of life appear not to have been impaired, when all the nerves of the lower extremities were destroyed. Not only did the parts,
destitute

destitute of nervous influence, retain their vital affinities, but exercised the most vigorous functions of life, that of uniting fractured bones and forming new gradulations.

But to understand a thing we must consider it in all the circumstances of its existence ; and to gain a knowledge of our subject, we must contemplate life, not only as pertaining to animals, but likewise to the whole vegetable creation, and observe what things constantly attend it, and are inseparable from it, in all the modes of its existence.

The life of vegetables is analogous to that of animals ; they possess many functions in common ; and certain circumstances are indispensable to its existence, in both. Like animals they are excited to the proper discharge of their functions by stimulating substances ; they elaborate and prepare their food in a way similar to animals, and like them they perform a variety of secretions, produce their growth, and perpetuate their species. They have glands, they have vessels, they have respiratory organs, and do exercise the functions of life, as perfectly as animals. Notwithstanding this, they possess neither brain nor nerves, nor do they exhibit any marks of sensation. Neither the Sensitive Plant, so much celebrated by Naturalists, nor the *Dionœa Muscipula*, or Venus' Fly Trap, the singularity of which is, that it clasps insects in its leaves with such power, as to destroy them, exhibit any other marks, than those of irritability, common to muscular fibres. Seeing, then, there are living existences possessing no brain, and parts having their communication with the brain destroyed in beings possessing it, do still retain their life, the unavoidable conclusion is, that life does not depend on the brain, but that the functions of this organ are entirely of a different nature.

But still, to show the absurdity, as well as the utter impossibility

impossibility that the principle of animation should be afforded by the brain, I would beg leave to suggest one consideration further.

It is not sufficient for our purpose to consider how life is prolonged, but we must likewise inquire how the first vital motions are produced, and what are the circumstances attending their production.

Animate beings are capable of producing their species. The different ways, in which they produce them, have laid the foundation for a division of animals into *viviparous*, and *oviparous*. Vegetables produce their species by seeds, which are in some degree analogous to the eggs of animals. Notwithstanding this variety of ways, the changes which take place, and the delineation of the embryo of each species are governed by much the same laws. What these may be, the egg affords us the best opportunity for inspection.

After incubation, what first appears is the heart and umbilical blood-vessels. In eggs, which I have examined, the heart was seen to beat distinctly two days before any traces of the brain could be discovered.—The same we learn, from good authorities, of *viviparous* animals. In all species of animals, the heart is the part first formed : it is here that vital action does first commence, and this is the organ which first exercises its function in the system. By the action of the heart and its appendages, the arteries, the other parts become distended and evolved. Now the first pulsation of the heart is as much dependent on the principle of animation, as the same action is at a time when the animal has arrived to that state, which is the standard of its species ; and by the same laws, the first particle of matter becomes assimilated to this organ, it is, that the body receives its growth and nourishment. All this, however, as we have seen, takes place before there are any vestiges of the brain, and some time before this organ

that

organ can be supposed to exercise its functions. Here, then, is the fullest demonstration, that the principle of animation is not afforded by the brain, as the functions of this organ are subsequent to the existence of life.—As we have noticed this phenomenon in the egg, those disposed to quibble, cannot escape its conviction, by saying, that the embryo is dependent on its parent for its first vital actions, as the egg is detached from the animal, which bears it. It is indeed wonderful, that any men should have supposed life to depend on a fluid secreted in the system, when the very production of this fluid must of necessity require life and vital action, in the system, in order to produce it. The supposition plainly carries this assertion, that a thing can at the same time act and not exist, than which there can be no greater absurdity. This consideration must be sufficient to silence every murmur, and demonstrate to the satisfaction of every one, that the principle of animation cannot be afforded by the brain.

Thus, I have considered those theories, on which the phenomenon of life has been most usually explained: I have, to my apprehension, found them insufficient and unsatisfactory. Not because they leave some points hard, and difficult to be explained, but because they are contradicted by experiment, and do not correspond with facts and observation.

It now remains to point out what this principle may be, and the source from whence it is derived.

In the first place, it may be useful to notice some considerations, which may serve to throw us into a proper channel of investigation.

We have considered life, and pointed out its characteristics. From the observations then made, we are led to consider those products of animate beings, designed by nature for the propagation of their species,

as void of life. This is evident, when we consider that life consists in certain actions before defined ;— that action implies change, and that seeds are kept for years without suffering any change, or alteration.— This observation applies to eggs, and is equally true, so far as it respects any vital change, in every species of animals.

Another consideration, leading to the same conclusion, is, that all living beings have a power of resisting putrefaction. Those affinities and combinations of matter, which take place in animate existences, are diametrically opposite to those, which take place in the same substances after death. The former may with propriety be called *vital*, and are those, by which the principles of the body become combined, its size increased, and its wastes repaired. The latter are called *chemical*, and are those, by which these principles become disunited, set at liberty, and the whole body disorganized. These different affinities, therefore, cannot subsist, and be going on in the same body, at the same time. Seeds of plants, and those products of animate existences, of which we are speaking, and by which their species are propagated, as they are first afforded, have neither of these actions going on within themselves. But there is a certain balance of affinities among their constituent principles, by which they continue the same without any change. As circumstances may favour, however, one or the other of these kinds of action now described, is liable to commence in their substance ; either a vital action, by which is produced another of the species simular to that which afforded the seed or egg, or else a chemical one, called putrefaction, by which its principles are uncombined and set at liberty. When the seed or egg is not attended with those circumstances, favorable for its receiving vital action, it possesses no power of resisting putrefaction, any more than the stock of the plant, or carcase of the animal, which gave it existence. We

We have now a view of what is to be understood by the *principle of animation* ; it is *that*, which is the cause of the *first vital action* in those different kinds of matter, by which the various species of animate beings are propagated ; and, which, continuing to be supplied, does maintain and support the flame of life, through all the varying stages of its existence. We must, therefore, look for something, which is as extensive as life itself, and which is present, with living beings, and consumed by them, not only when arrived to the standard of their perfection, but likewise, which is afforded the embryo, and the germ in their most rude and imperfect state, and, which being withdrawn, leaves all animated existences to die !

Led by these different inquiries to the consideration of life in the various circumstances of its existence, I am induced to believe, that *Oxygen* is the principle of animation, that it is received into the system from the atmosphere by the respiratory organs. So far as it can be proved by observation and experiment, that oxygen is received by every living existence, that it is of indispensable necessity, in order to the first excitement of vital action in the eggs of animals, and the seeds of plants, and on its being withheld, that life does immediately become extinct, so far, I conceive, this opinion will gain belief, and escape the censure of temerity, and the reproach of folly.

It is now generally known, that the atmosphere is a heterogenous fluid consisting of two different kinds of gas ; one maintaining combustion and animal life, existing in the proportion of about 27 ; the other contributing to neither, the proportion of which in the atmosphere is estimated at 73. The former is called *oxygen, vital air, highly respirable air, dephlogisticated, or empyreal air* ; the latter has obtained the name of *nitrogen, septon, azote, or phlogisticated air*. That oxygen is
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the principle of combustion, has been proved by the experiments of M. LAVOISIER, and others ; the foundation of our belief for supposing it the same of animation, I proceed now to show in the order before intimated.

Every one knows that respiring animals take air into their lungs, and that air, which, has once been breathed, is then unfit for respiration. But on what this phenomenon depended was not known till Dr. PRIESTLY discovered, that in the act of respiration, oxygen was absorbed from the atmosphere, through the thin membrane, which separates between the bronchia and blood vessels ; and, that deprived of this, in some way or other, animals do immediately die.—It is further proved, likewise, that the blood having thus received the oxygen, acquires an additional degree of heat, and a florid colour. These propositions having been already sufficiently established by various writers, I proceed to take notice that something similar to this takes place in all living existences.

M. LAVOISIER has demonstrated that oxygen is one of the constituent parts of water, and, likewise, that water contains air in its pores. Fishes, therefore, are not excluded from this vital fluid. Notwithstanding the symptoms of uneasiness, distress, and even death, which happen to them, when removed into the atmosphere, yet they can no more live without air, than those animals, which inhabit the land. Fishes are provided with gills, which serve for them the place of lungs. These are composed of a vast number of red *fibrillæ*, subject to perpetual motion from the water. Through these the blood circulates, coming from the heart ; it is here again collected by small veins, which uniting, form an *aorta*, by which the blood is carried to all parts of their bodies. That the blood is here oxygenated, as in the lungs of other animals, is very certain

certain from analogy. The blood, in both, undergoes the same changes ; that in the gills of fishes appearing extremely florid, like that in the lungs of animals. In either case, that portion of the element respired has no longer the power of supporting life, consequently, a renovation is continually required. Fishes exhibit the same symptoms, when deprived of oxygen, that other animals do—violent convulsions, and immediate death. In severe winters, when much of the communication of the air with water is intercepted, by means of ice, many of these animals die ; by opening the ice, and admitting the air, they rush violently to the surface of the water, with such eagerness for air, that they oftentimes suffer themselves to be taken by the hands of the fishermen.

Insects, likewise, are provided with organs for receiving air, called *tracheæ* ; these being besmeared with oil, they soon die.

Oxygen is not only necessary to the life of all animals, but, likewise, to that of all the vegetable creation. That the sap of plants circulates through their leaves, has been ascertained by experiment. On the upper surfaces of them, the sap is exposed to the action of the atmosphere, beneath a thin pellicle. Here it undergoes a change, and is carried back by vessels on the under side of the leaf. A stalk having been placed, several days, in a decoction of madder, on the upper surface were seen many red arteries going to the extremities of the leaves, which were not visible on the under side. On cutting across a leaf, by the help of a lens, the returning vessels, on the under side, were seen to discharge a milky fluid, but none of the red fluid, contained in the vessels, on the other side of the leaf. The upper surfaces of leaves, likewise, being covered with oil, they soon die. The leaves of plants, therefore, have an office similar to the lungs in animals,

tracheæ

tracheæ in insects, and gills in fish. Excluded from the air, they decay and die, as has been proved by the experiments of SCHEELÉ, and others.

Thus it appears that all living existences do consume oxygen. This, however, is not only necessary to the continuance of vitality, but without it, neither the embryo of animals, nor the seeds of plants can be ushered into life. The first attention of nature, in the production of all the myriads of her existences, appears to be to make provision for a supply of this oxygen gas.—While as yet there are neither vessels, nor organs for receiving it, this vital principle is necessary to excite the first motions of life ; at this early period therefore, there is a mechanism peculiarly fitted for that purpose.

This, in viviparous animals, is the placenta ; its function is analogous to that of the lungs, after the foetus is delivered from its parent. It appears from the opinions and experiments of respectable writers, that there is no circulation of blood between the parent and the foetus ; but that the blood of the foetus is carried to the placenta by an artery, and is there distributed to its extremities, and again brought back by veins. This appears, from this circumstance, that the placental vessels do not bleed when torn from the uterus, while those of the uterus discharge a large quantity of florid blood. This is accounted for by Mr. J. HUNTER. “That ingenious philosopher,” says Dr. DARWIN, “has shown that there are numerous cavities, or lacunæ formed on that side of the placenta, which is in contact with the uterus ; these cavities or cells are filled with blood from the maternal arteries, which open into them, which blood is again taken up by the maternal veins, and is thus perpetually changed ; while the terminations of the placental arteries and veins are spread in fine reticulation on the sides of these

these cells." From this relation it appears evident, that the placenta receives the blood for the purpose of oxygenation ; the same is further confirmed by the changes the blood there undergoes, which are the same as those it suffers in the lungs of animals.

In oviparous animals producing their young from eggs detached from the parent, this process of oxygenating the blood is not possible. Thinking, however, that oxygen must some way be communicated, I made the following experiments.

EXPERIMENT 1st.

In the large end of the egg it is well known there is included a small bag of air. Having procured a number of eggs, I collected a quantity of this air in a glass tube, in contact with which I put a solution of sulphure of potash, a property of which is to absorb oxygen. Part of the air thus enclosed was soon absorbed, after which there remained a portion of azote.

EXPERIMENT 2d.

Having ascertained that eggs do contain oxygen within their shells, I wished to know its importance in the incubated egg. For this purpose, I took a number of eggs, and having broken the shell into the air bag, I completely filled the cavity with a dosil of lint, soaked in glue ; over this I spread a varnish, so as totally to exclude the air. These eggs I put under a setting hen, together with other entire eggs. On the fourth day of incubation, I examined them ; in those which were put under entire, was distinctly seen the heart of the future chick beating, together with the umbilical blood-vessels, beautifully ramified, and appearing exceedingly florid. At this time, in the place of the head, was seen a dark speck, which did not appear two days before, notwithstanding the heart and blood-vessels were evident, as on this day. In those eggs, whose shells

shells had been broken, and the air, they contained, excluded, no vital action had been excited ; on the contrary, putrefaction had evidently commenced.

EXPERIMENT 3d.

In another parcel of eggs, having opened into the cavity, or air bag, I introduced sulphure of potash, and sealed it close with varnish, as in the other experiment. This absorbed the oxygen, only, leaving the azote still to occupy the cavity. These eggs being subjected to incubation, the result was the same as in the preceding experiment ; not one of them hatched.

From some disappointments, and the inconveniency in my present situation, of making these experiments, I have not pursued this inquiry so far as I had intended ; but that oxygen is contained within the shell of the egg, to be of use at the time of incubation, I think is evident from the experiments I have related. For without the presence of this, the *cicatricula* of eggs is not animated, no part evolved, nor does it assume any action of life. At the time of making these experiments, a woman of more than common observation informed me, she had a hen among her poultry, in whose eggs this portion of air was always wanting, and that not one of these eggs had ever hatched, although trial of them had been repeatedly made.

We are, therefore, led to this conclusion, that in consequence of the heat, which the eggs acquire by incubation, the oxygen becomes active, and that in this way the first vital motions are produced ; that it continues to oxygenate the blood till the time the chick is extricated from its shell. This will be evident to any one by inspection, who will take the trouble to examine an egg, some days after incubation. Then may be seen an almost infinite number of blood vessels spread on the membrane, which confines the air in one
end

end of the shell ; these vessels are collected, and form the umbilical artery, which leads to the heart. That the blood is carried here, for the purpose of oxygenation, we have no cause to doubt ; the appearance makes it almost certain. These vessels appear extremely florid, and of a bright red colour, whereas, the vein, which is spread on the albumen, appears of a dark modena.

We have next to examine, what part oxygen has in the germination of seeds. Seeds, when sown, are in such a situation that the air communicates with them freely. That provision, therefore, which is made to supply animals with oxygen, at an early period of their existence, is not necessary for plants ; still, to determine what office oxygen might have in their vegetation, I made the following experiment.

I put into a glass globe a handful of beans, a little water, and stopped it close, it being filled with atmospheric air. In this situation, it stood a week, in which time the seeds sprouted, and grew half an inch. I then unstopped the vessel, having immersed it in water.—On withdrawing the stopper, the water rushed in, and the air remaining was found to have lost every particle of its oxygen. The seeds had begun to putrefy, which I suppose to be in consequence of the oxygen having been consumed, before the globe was unstopped ; the vital principle, then, not being afforded, the actions of life could no longer be continued—chemical affinities were therefore suffered immediately to take place.

Such are the facts we have been able to collect, to show, that at the first dawning of life, vital action is excited and kept up by oxygen. We know it, because eggs and seeds are not animated without it, because nature has invariably made provision for its supply, and because in all instances of life it is consumed.

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The necessity of respiration to animals, through the varying stages of their existence, could not escape the attention of man. The observation has been made from time immemorial, but its use in the œconomy of life was not till lately known, nor even yet has its full importance been acknowledged. By this way oxygen is supplied to the system, which in some way or other, as we have seen, is afforded to all living existences.

Mr. CRUIKSHANK, in his experiments on the reproduction of the nerves, relates one, from which, I think, he might have drawn more important inferences than he has. It shews in a striking manner the importance of respiration, and how, independently of the brain, the functions of life are exercised.

Mr. CRUIKSHANK took a dog, and by detaching the scapula from the spine, divided all the nerves of the *axillary plexus* on each side. He then divided the spinal marrow between the last vertebræ of the neck, and the first of the back, and likewise the parvagus and intercostal nerves. In this experiment, all communication of the heart, lungs, diaphragm, and thorax with the brain, was cut off. The whole animal took the alarm; all the flexor muscles seemed to contract, and instantly to relax again; all appearances of life were gone. He then opened the chest, and found the heart had ceased its motion. Then he introduced a large blow-pipe into the trachea, below the cricoid cartilage, and inflating the lungs, imitated respiration. The heart began to move again, and in about three minutes was beating 70 times in a minute. After some intermission, this was again repeated, and continued for half an hour, the heart and arteries beating regularly all that time.

This experiment shews that respiration is the prime mover of the machine; and that the nervous influence, whatever

whatever it may be, serves merely as a stimulus to excite the action of the muscles and diaphragm, thereby to enlarge the thorax and favour the admission of air into the lungs. Further, it explains, what at first thought, might seem difficult to be accounted for, that the chick, before the formation of the brain, will have its heart beating, whereas after its complete formation, and it has escaped from its confinement, the nervous influence is necessary in order to the continuance of this action. By this experiment, it appears, that nothing but a sufficiency of oxygen is necessary to the action of the heart, and that the brain does contribute to this action by opening the way for this supply.

Animals subjected to inhale the same air, without renovation, soon die ; that death in this case is in consequence of a deficiency, or want of oxygen, and not from noxious vapour thrown off from the lungs, we know for this reason ; that animals confined in any other gas, however pure, or in the exhausted receiver, die with the same train of symptoms. When the usual proportion of oxygen in the atmosphere is diminished, life languishes ; but the moment this proportion is increased, the powers of life become invigorated, the functions are performed with alacrity, and the whole system seems to have acquired a new degree of animation.

From a review of these observations, we may learn what advances have been made in favour of our subject.

Irritability we considered as the characteristic of life ; and in those actions, by which the functions of living beings are performed, does life consist. Seeds of plants and those products of animated existences, by which their species are propagated, we considered as void of life, not possessing those actions in which

life consists. In these, likewise, we have proved by observation and experiment, that vital action does not take place without the presence of oxygen, that the embryo of viviparous animals receives it from its parent; in oviparous animals it is afforded the young in the shell; that seeds in the time of germination do absorb it from the atmosphere. That a constant supply of this is necessary to every living being, for the support of life, through the varying stages of its existence—not an insect moves, nor a plant shoots its branches, but by the instrumentality of this universal diffuser of animation.

These considerations are sufficient to justify us, in our opinion, respecting its importance, in animation; and should any doubts remain, perhaps further experiments and observations, may remove them, and finally enthrone science in those regions, which too long have been occupied by fancy and conjecture.

Let it not be thought an objection to this theory, that oxygen is something, whose existence is made certain, and many of whose properties have been ascertained by experiment; and because the chemist, in his laboratory, has not been able to excite life in those substances, with which he has combined oxygen, that, therefore, nature is incapable of the operation.

It has been common, with philosophers, in attempting to develop the mysteries of nature, when, from the concurrence of known causes, an effect has been produced out of the way of their common course of operation, in other circumstances, to suppose that an unknown cause cooperated to produce this effect. But till the relation of things are all perfectly understood, and every combination of matter known, we may expect continually to be ascertaining new properties, qualities, and effects, of those things, which are the objects of our senses.

In things, which men do not understand, they are always prone to run into great prolixity, and vain imagination. Nature is uniformly more simple, in her operations, than the bigotted opinion of man is wont to conceive. She proceeds to her object by direct steps, but man wanders a devious way, and thinks to pursue her, like the wily fox, through mazy windings and intricate paths.

When philosophy shall have withdrawn the veil, from the eyes of mortals, and disclosed to human view, her operations, then will be seen the uniformity that so constantly marks her steps, and that simplicity, which pervades all her works.

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